Overview of Planar shielding results and methods

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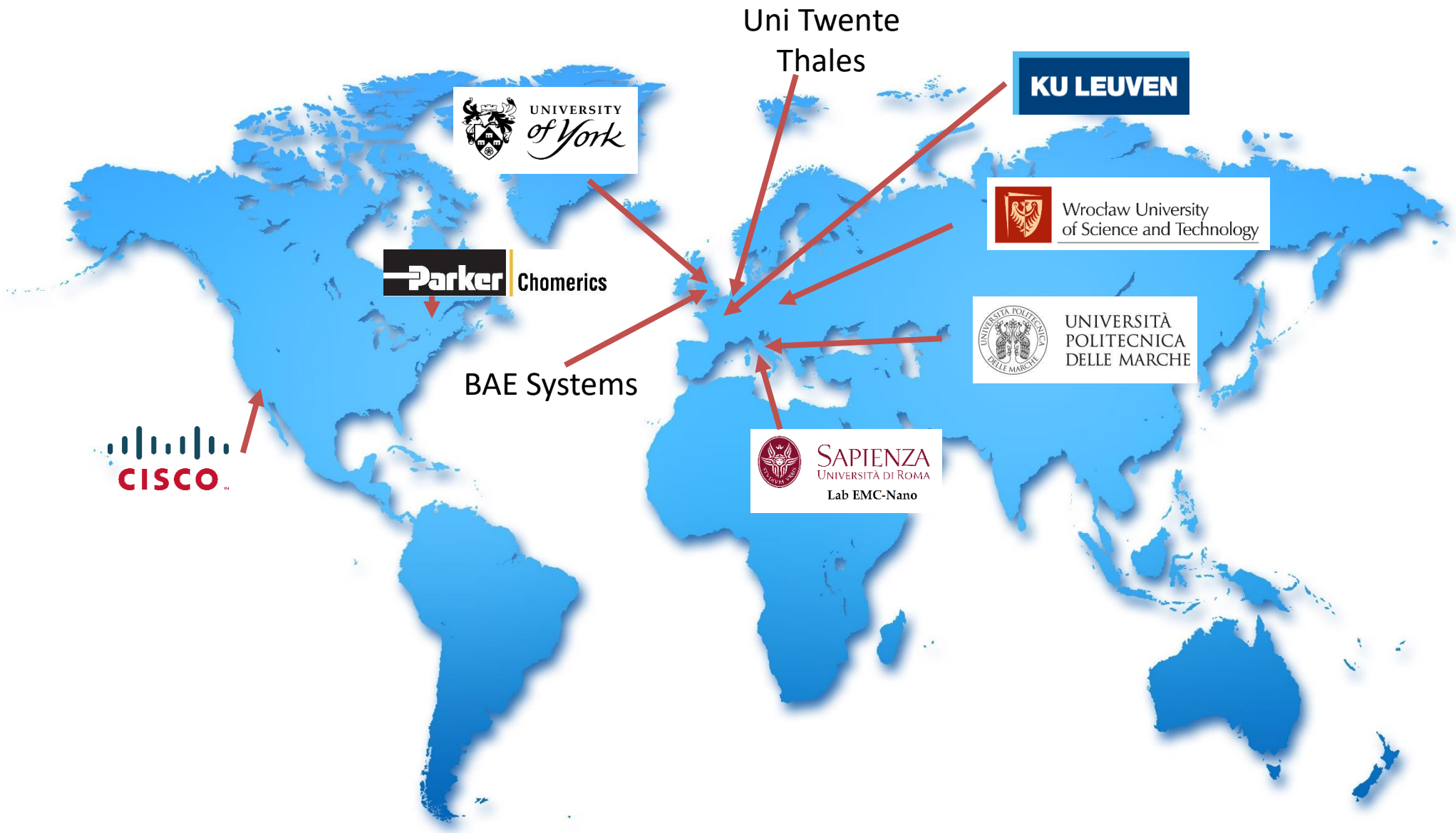
Dawson, J.; Arien, Y. & Pissoort, D. , "Overview of the P2715 WG - IEEE Guide for the Characterization of the shielding effectiveness of planar material:Overview of Planar Shielding Results and Methods" , Electromagnetic Compatibility (EMC), 2019 IEEE International Symposium on , 2019



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So what's the difference ?

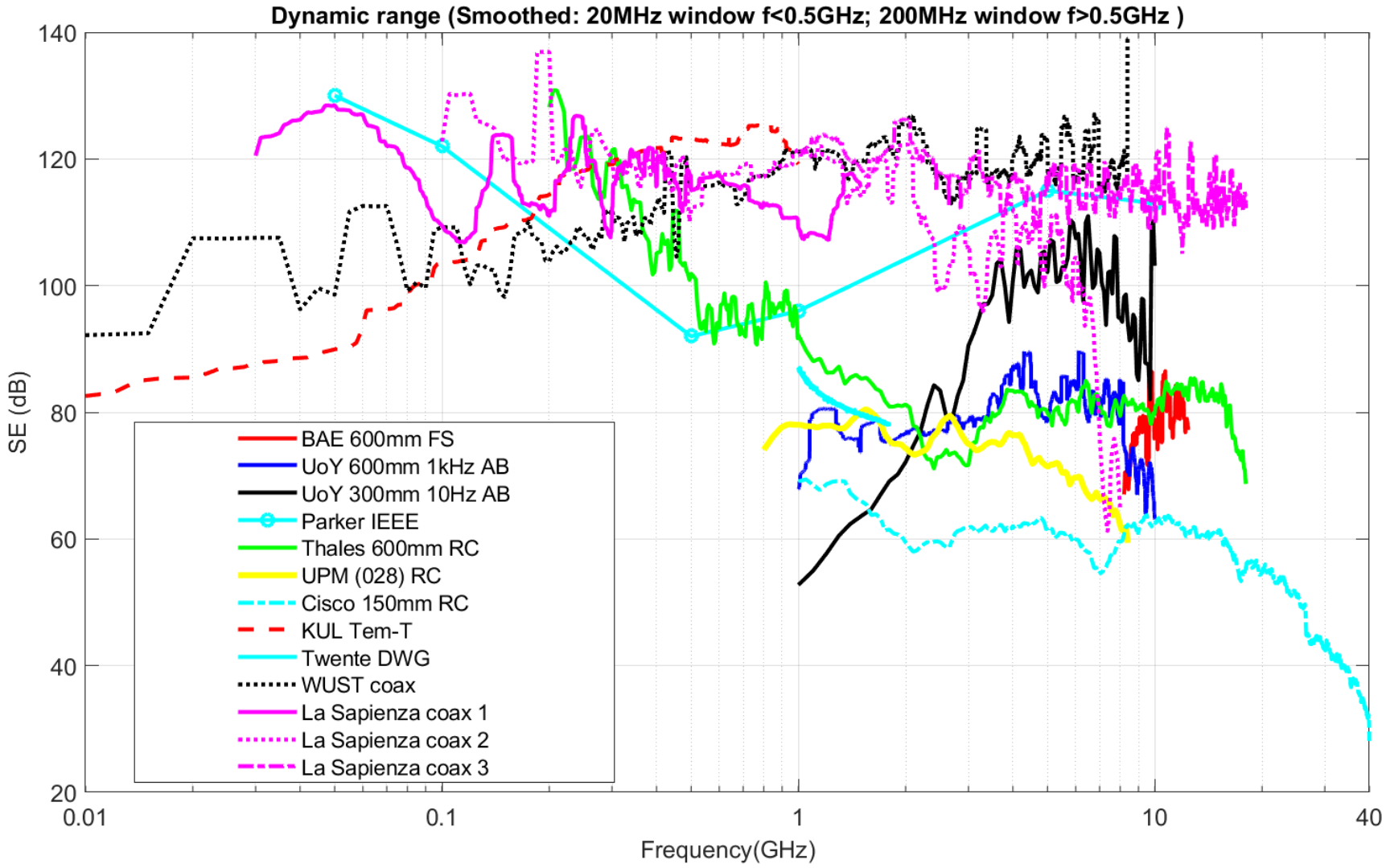
- Standard method ?
- Dynamic range
- Frequency range
- Sample preparation
- Anisotropic materials
- Physical size
- Accuracy of results
- Equipment required
- What is measured

Standards

- Standardized SE measurement techniques
  - ASTM D4935-10:Standard Test Method for Measuring the Electromagnetic Shielding Effectiveness of Planar Materials
    - valid over a frequency range of 30 MHz to 1.5 GHz

- SE measurement techniques derived from standardized techniques
  - IEEE 299: Standard method for measuring the effectiveness of electromagnetic shielding enclosures
  - IEC 61000-4-21: Testing and measurement techniques – Reverberation chamber test methods
    - (Nested) reverberation chambers
    - Vibrating Intrinsic Reverberation Chamber (VIRC)

Dynamic range



Comparing the dynamic range reported by the participating labs

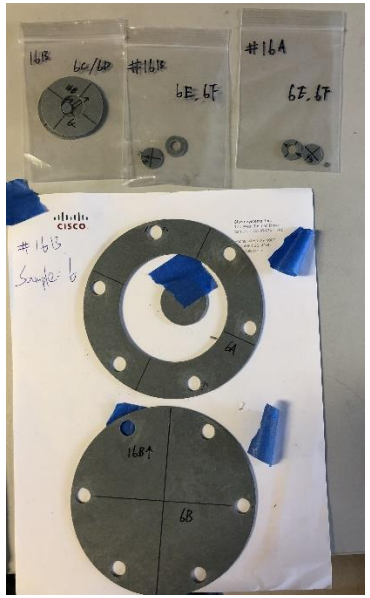
- The dynamic range depends on the measurement instruments and settings as well as the method.
- The coax method tends to have the best dynamic range as there is no jig insertion loss
- Jig leakage around the sample may further limit the dynamic range – but this effect is not seen in the measurement which is usually done with a metal plate. With a real sample jig leakage is more of a problem if the surface is non-conductive.

Frequency range

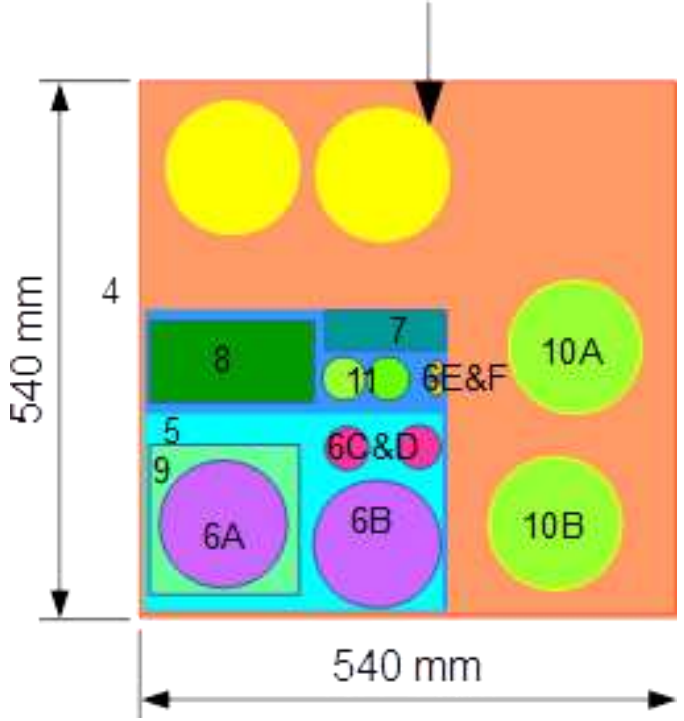
- Freespace:
  - limited by need to have sample many wavelength big
- Absorber box:
  - Currently 1-10GHz (limited by antennas and absorber size)
- Reverberation chamber:
  - >200MHz (depends on chamber size)
- IEEE 299:
  - 50MHz – 10GHz (Depends on chamber and setup)
- TEM-T
  - 10MHz-1GHz
- Coax ASTM
  - dc – 18GHz (needs smaller coax for HF, sample surface may limit LF)

Sample preparation

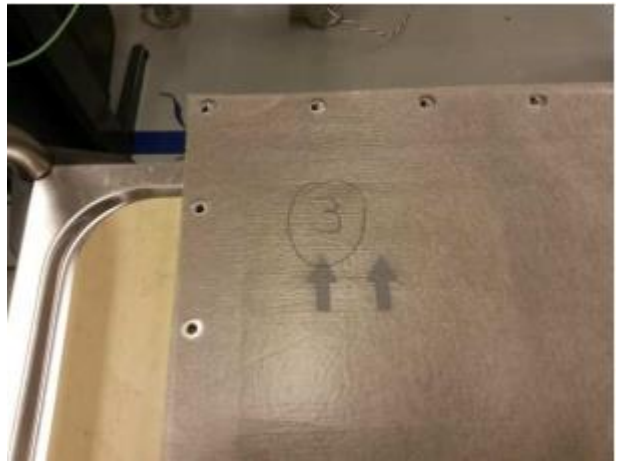
- Most methods require that the sample be cut to size and drilled to match mounting holes
  - AB & FS are simpler
- Most methods are affected by the surface conductivity – non-conductive surface may cause leakage
  - AB & FS are not, Coax can compensate



Coax samples



Sample cutting plan



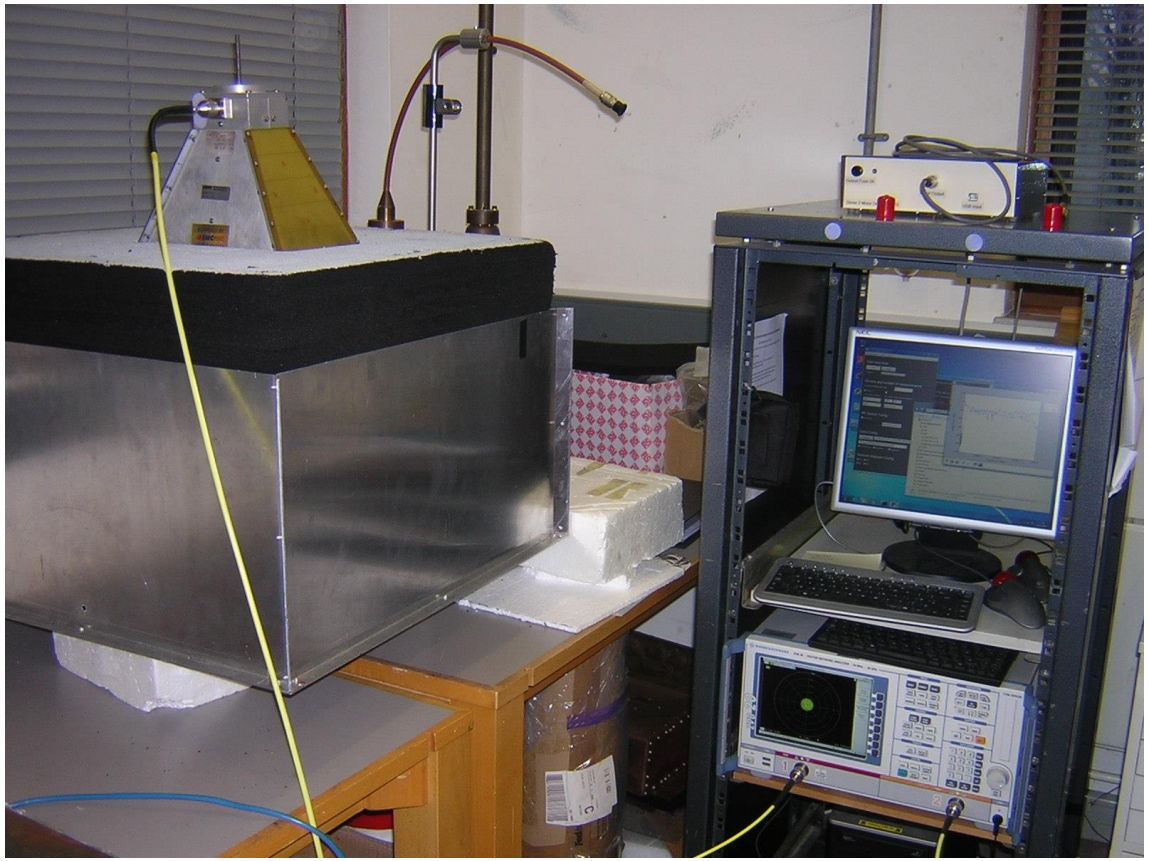
Reverb sample

Anisotropic materials

- Some methods average over a number of polarizations so cannot detect anisotropy in the sample:
  - Coax, Reverberation chamber
- Reverberation chamber averages over all angles of incidence
- Other methods have a single angle of incidence
  - Free-space, Absorber box, Coax, TEM-T, Dual waveguide, Dual TEM, IEEE-299
  - These methods can measure SE for different sample orientations and so quantify anisotropy

Equipment required

- All use similar instruments
  - Vector network analyser (VNA) or,
  - Signal generator and receiver
- Just different test jigs
- Actual performance depends on jig and instruments:
  - Source power
  - Receiver noise-floor
  - Jig and cable leakage
    - Jig leakage may depend on sample



Absorber Box measurement setup:
VNA, cables, 2 antennas, Absorber box

Physical size

- Chamber methods
  - Several meters in each dimension
- Free space method
  - A few wavelengths (~ 1m cube here)
- Absorber box
  - 600mm cube for 1-10GHz range
- Coax
  - 100 diameter x ~300mm long
- TEM cells
  - ~300 mm cube

Coaxial jig

IEEE 299 dual chamber setup

Dual TEM cell

What is measured?

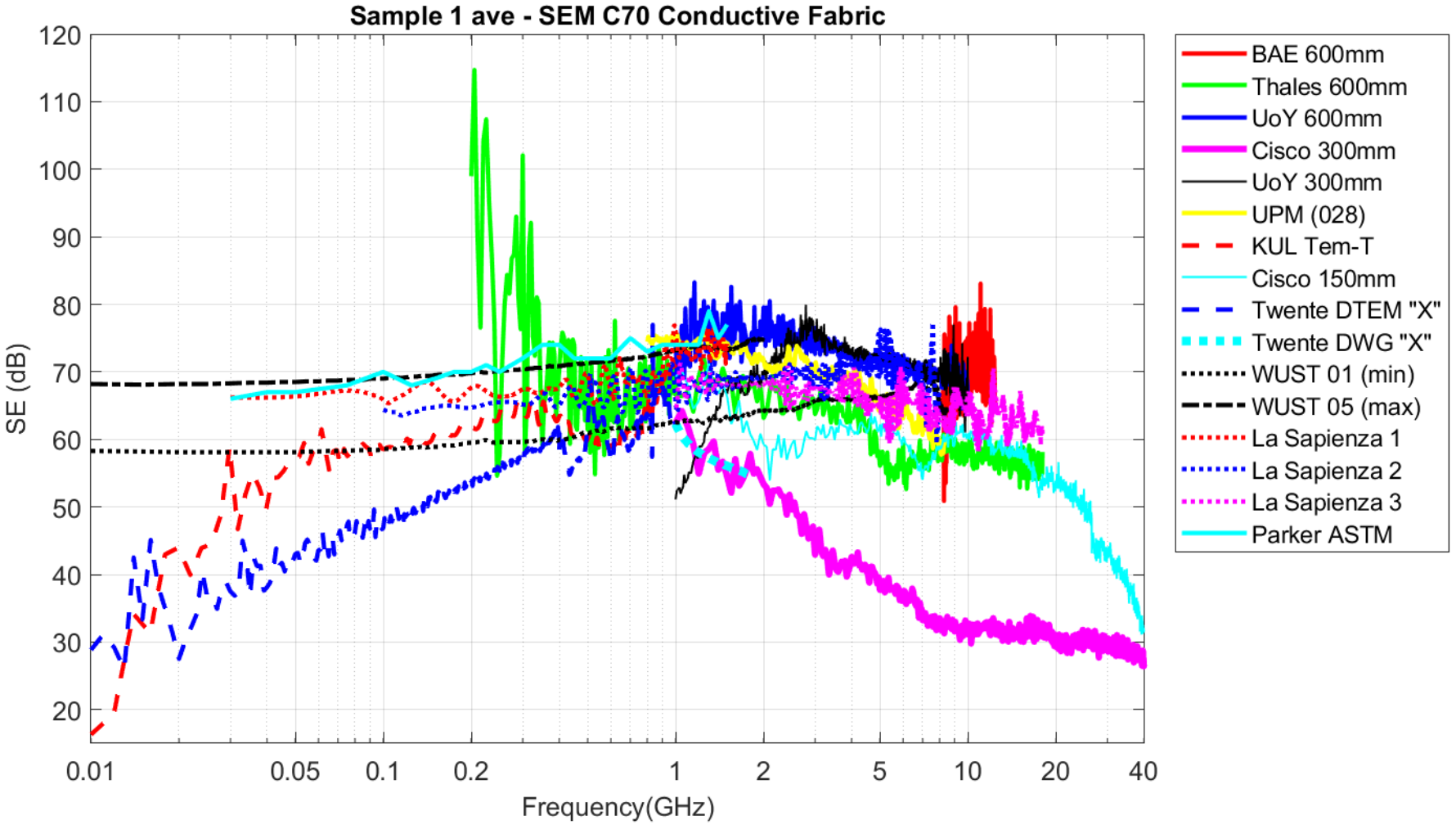
- Plane wave, Waveguide mode, Reverberant field
- Other?
- How should we compare these ?
  - In this presentation the SE measured on the single polarisation jigs (FS,AB, TEM-X,DWG) was averaged over both polarisations for comparison with the methods which measure over a range of polarisations and angles:

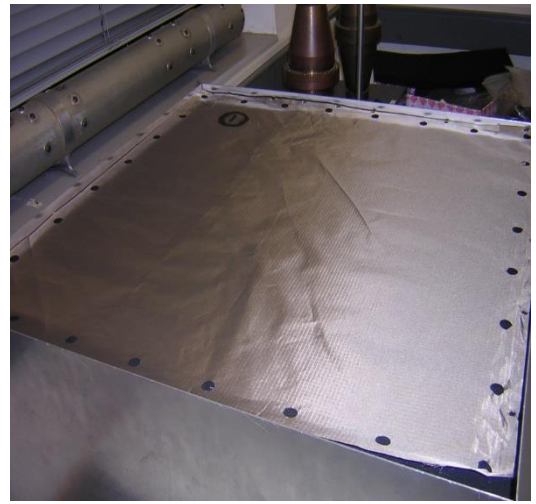
$$\overline{SE} = \frac{1}{\frac{1}{2\pi}\int_0^{2\pi}\sqrt{\left(\frac{\cos\theta}{SE_x}\right)^2+\left(\frac{\sin\theta}{SE_y}\right)^2}\,d\theta}$$

where $SE_x = \frac{E_{0x}}{E_{tx}}$ is the ratio of incident (E_{0x}) to transmitted (E_{tx}) field in one polarisation and $SE_y = \frac{E_{0y}}{E_{ty}}$ is the ratio measured in the orthogonal polarisation.

- For Coax, and reverb the values are presented as measured.

Results comparison





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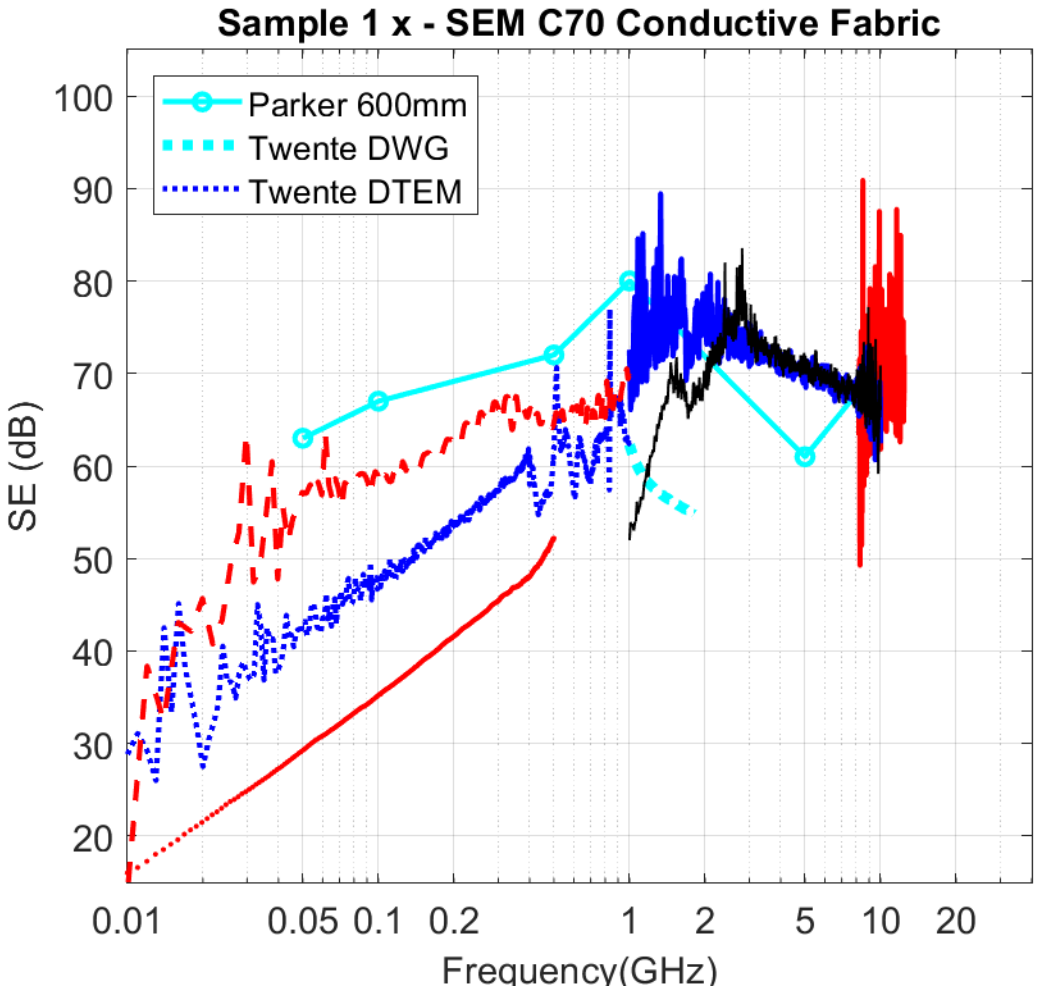

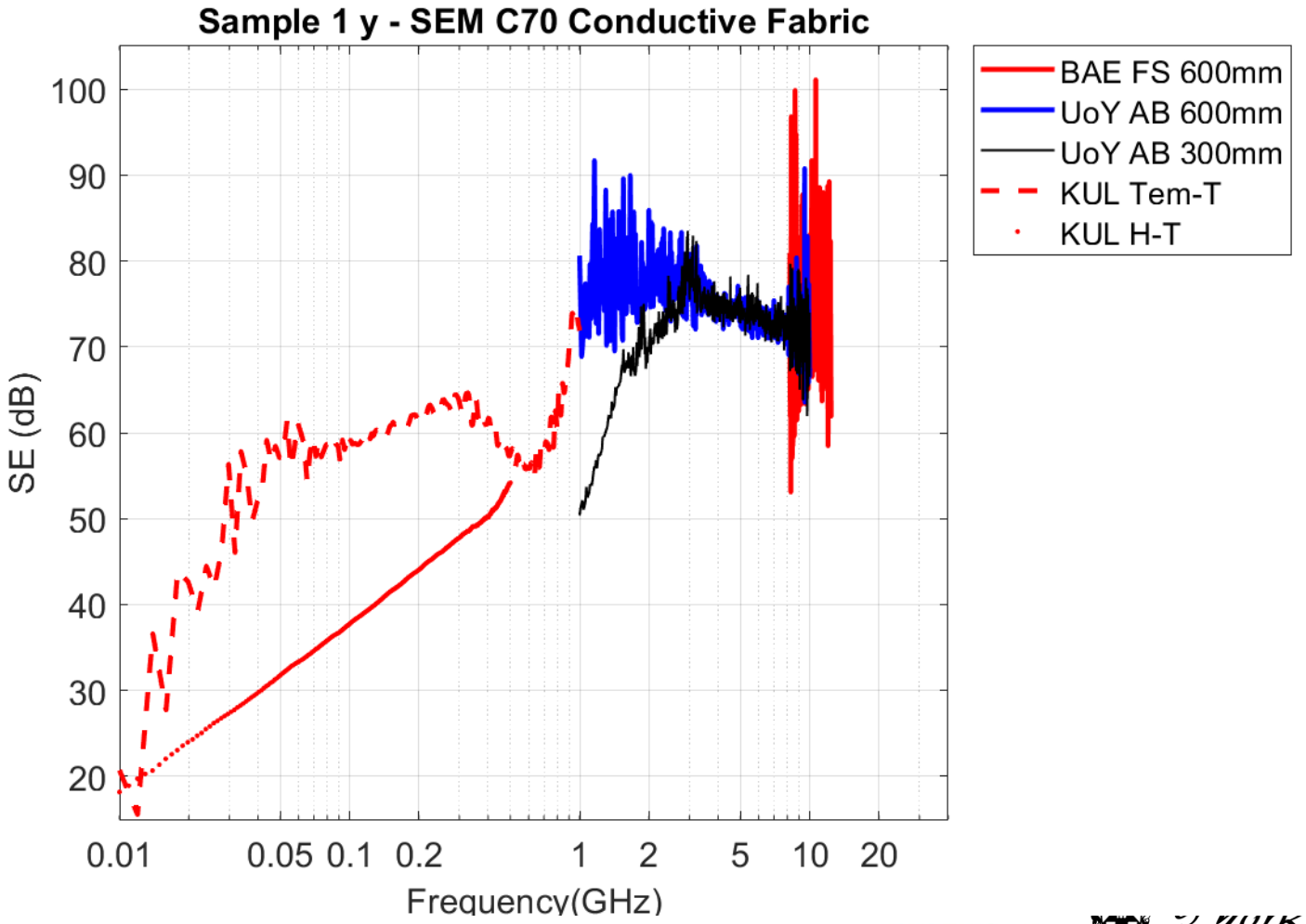

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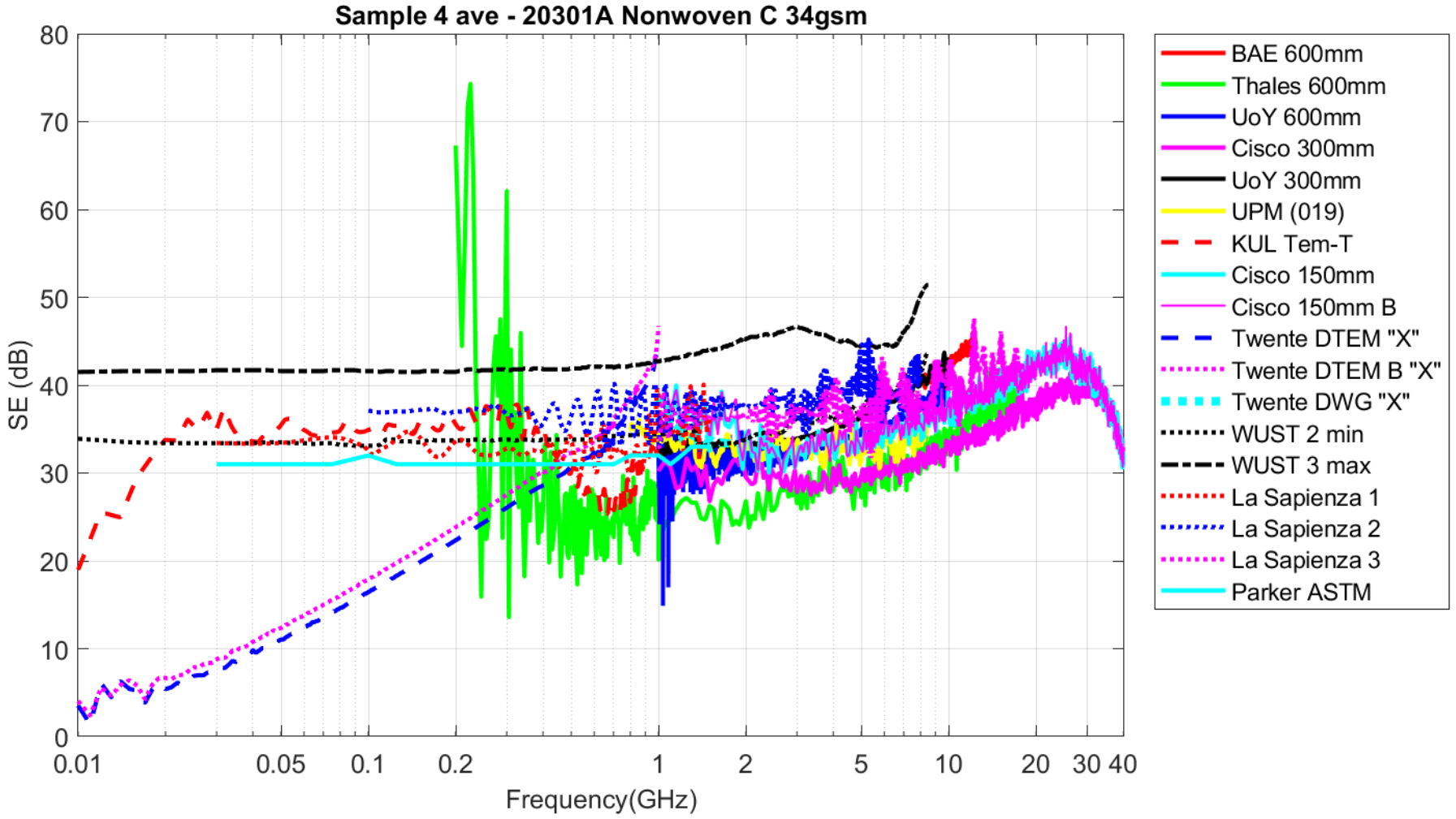

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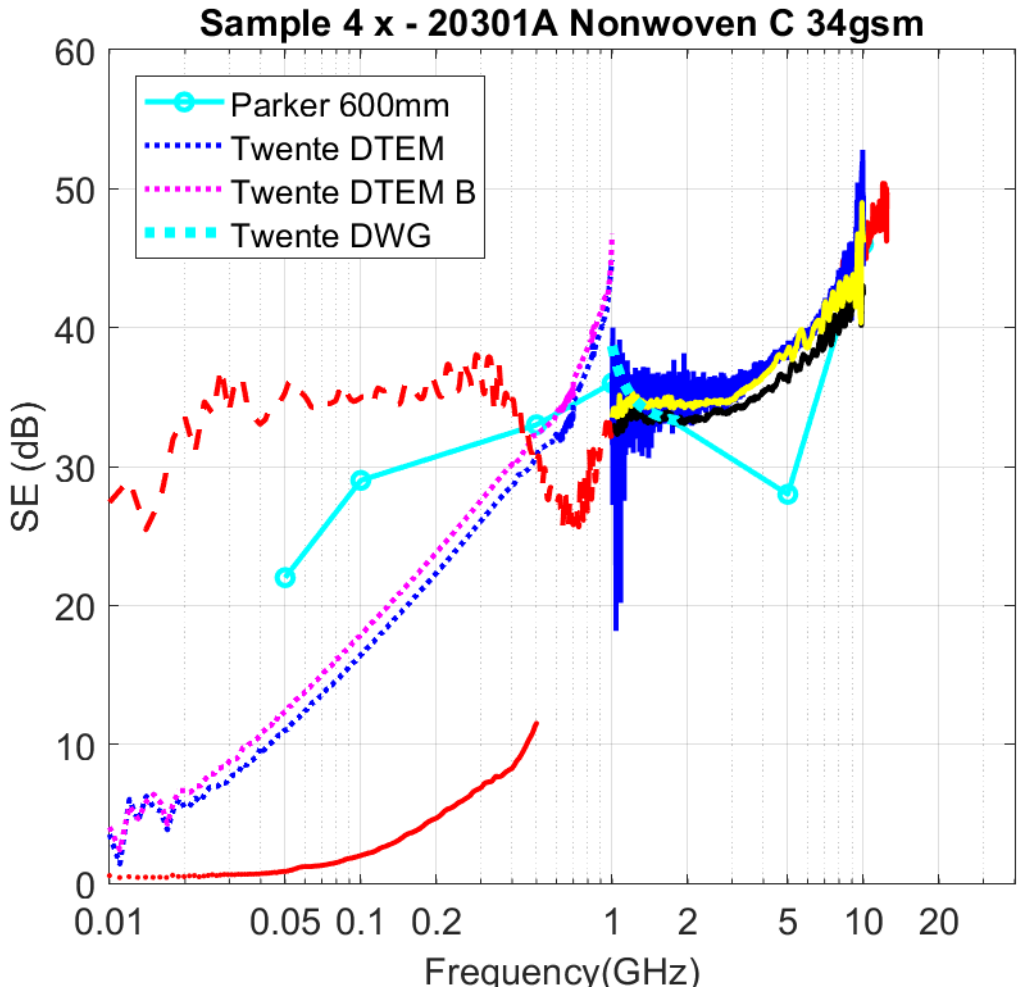

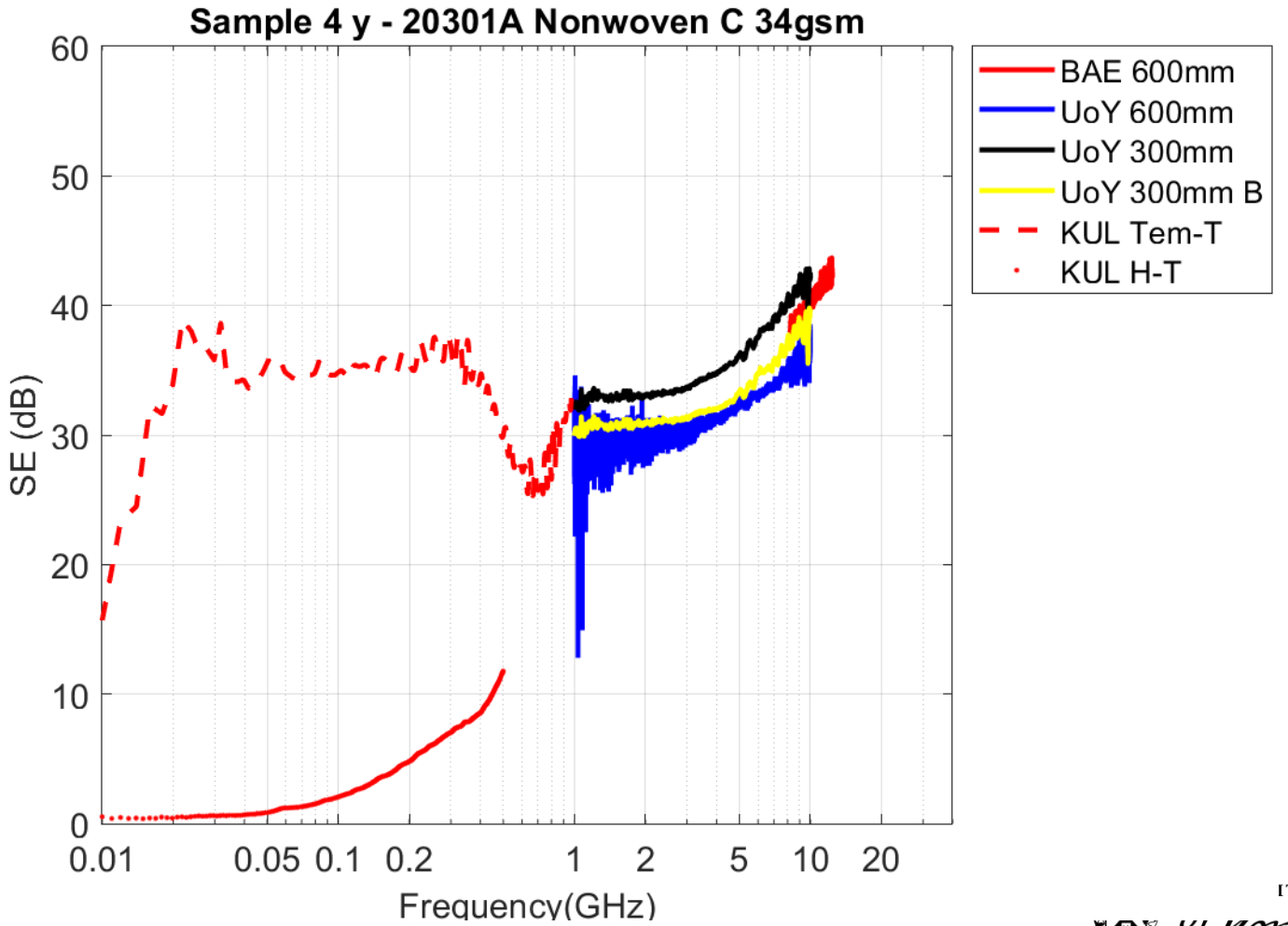

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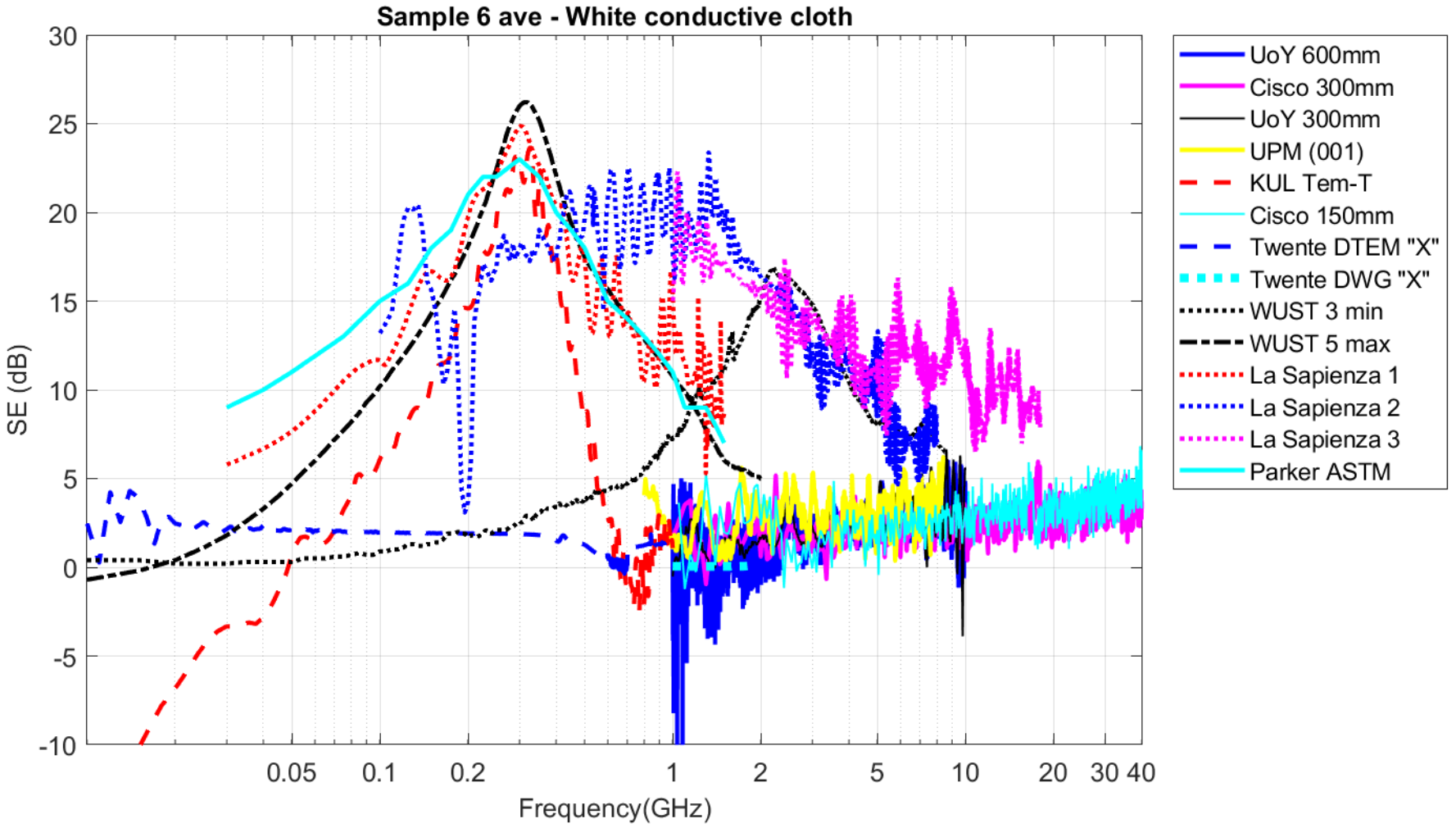

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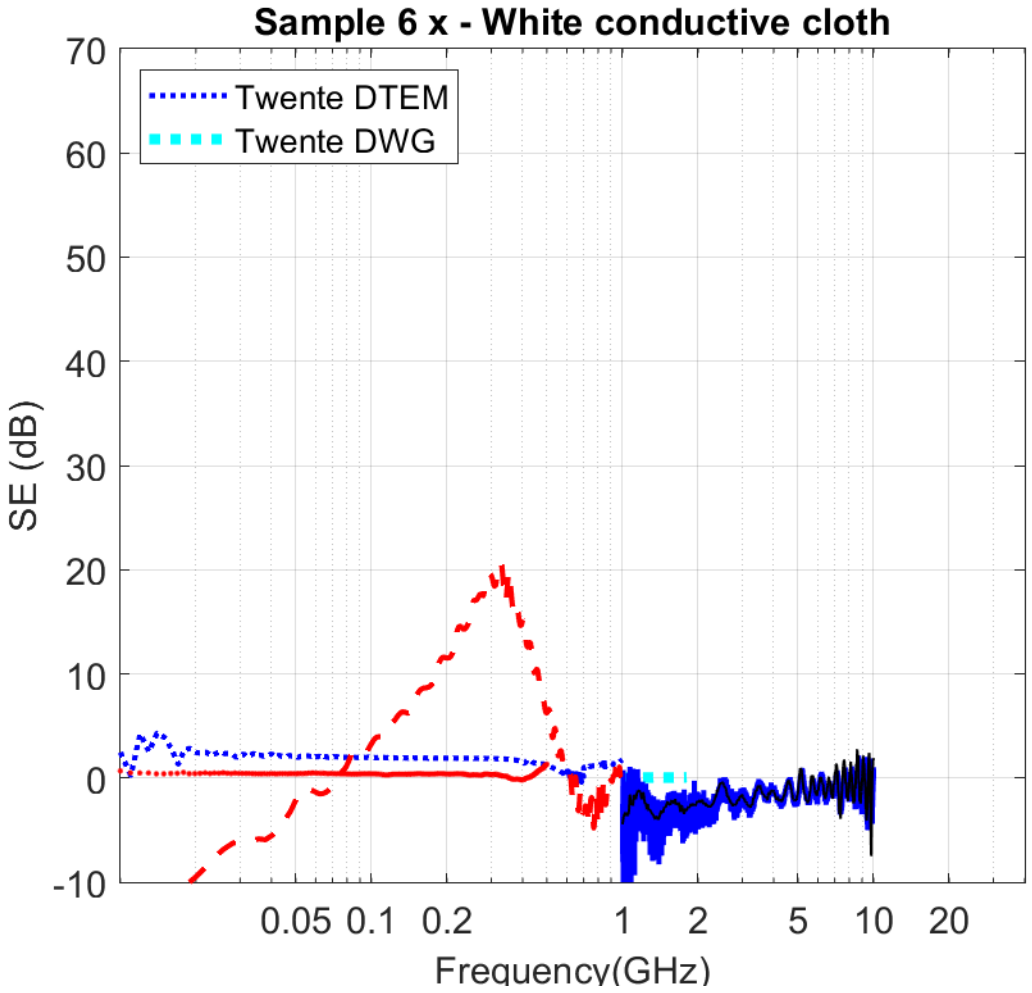

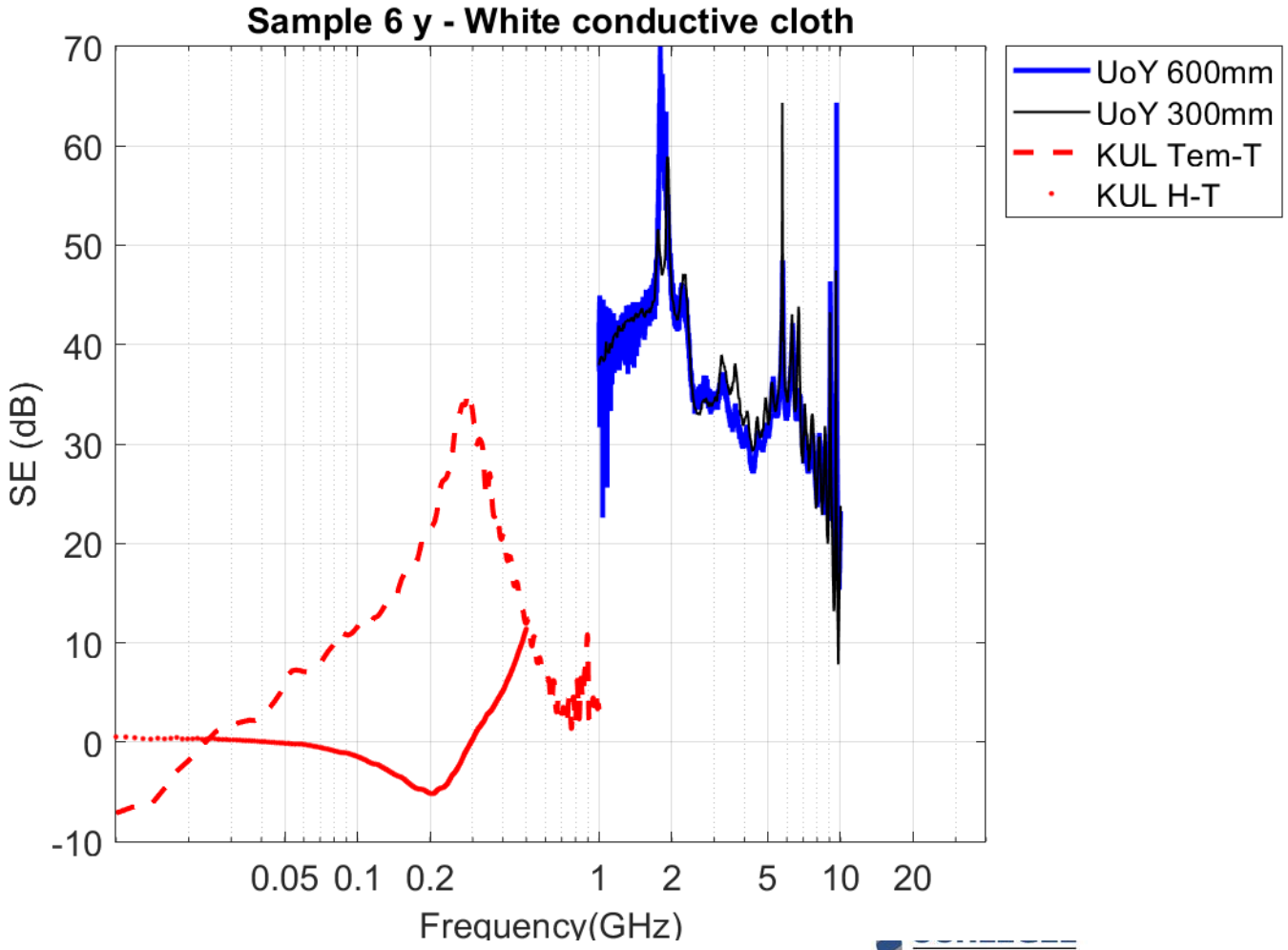

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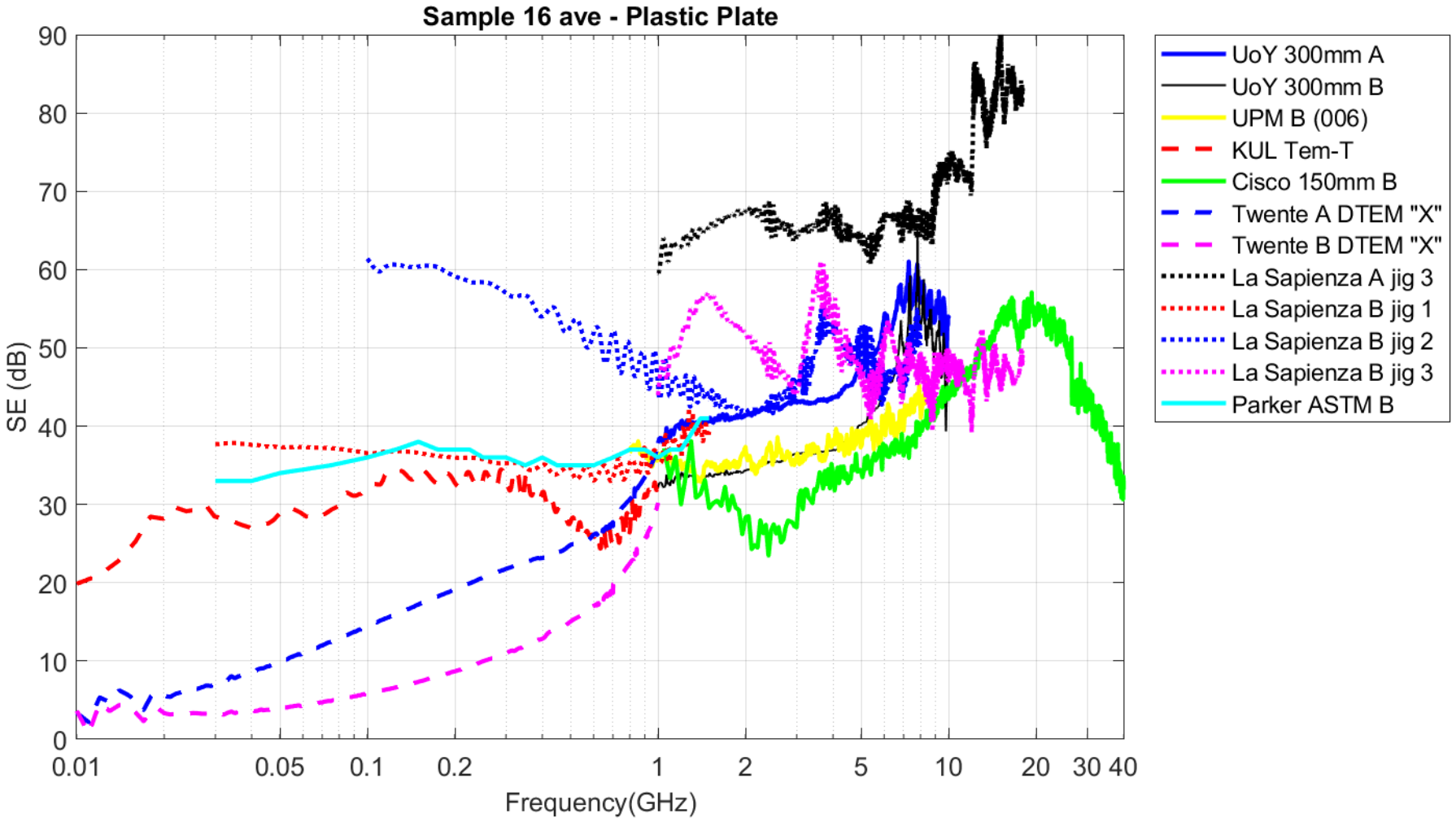

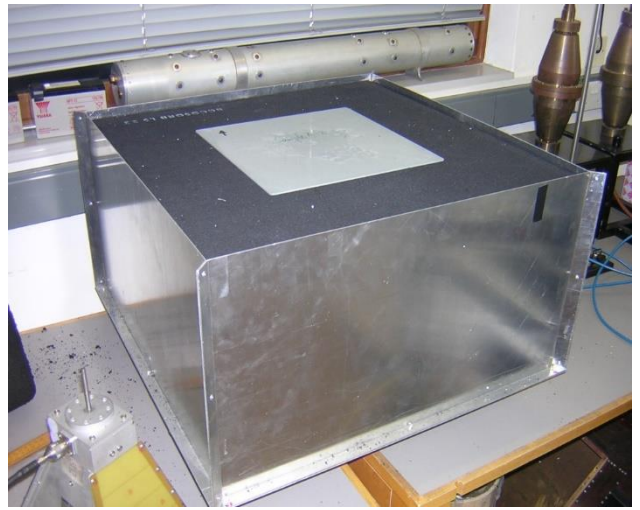

Conclusions

- No best method
  - Material dependent
- Test results needs to compared to Dynamic range
  - Dynamic range is limited in high frequencies (>20GHz)
- Jig leakage limits the accuracy
- Some significant variation between different samples of the same material
- Some strange jig dependent behaviours for some materials.

- SE measurements are not easy!